Assessing the Impact of Various Protective Barriers and Bleaching Agents on the Fracture Resistance of Teeth Following the Walking Bleach Technique: An in Vitro Study

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Abstract: ***Aim**: This study will aim to evaluate the effect of three different commercially available protective barriers and bleaching agents on root canal-treated teeth. **Materials and Methods**: Twenty-seven freshly extracted single-rooted incisors, canines, and premolars will be collected and stored in normal saline. Root canal procedures will be performed on the extracted teeth, and these will be classified into three groups with three subgroups (n=3).Group 1: Resin-modified glass ionomer cement (RMGIC) (Prevest Fusion i-Seal) will be placed at the level of the cementoenamel junction (CEJ) and cured for 30 seconds.Group 2: MTA (Prevest Denpro MTA Plus Aqua) powder and liquid will be mixed according to the manufacturer's instructions and placed at the level of the CEJ, and the mixture will be allowed to set for 1 hour. Group 3: Flowable nano-hybrid composite (G-ænial Universal Flo, GC Corporation) will be placed at the level of the CEJ. Group A will be treated with 35% carbamide peroxide. Group B will be bleached with 35% hydrogen peroxide and sodium perborate. Group C (control group) will be treated with distilled water. The bleaching procedure will be repeated once every seven days for a period of three weeks. After bleaching, each sample will be sectioned 2 mm above the level of the CEJ to remove the crown. A universal testing machine (UTM) will be used to evaluate the fracture resistance of the teeth.*

Keywords: intracoronal bleaching, fracture resistance of teeth, protective cervical barriers, root canal treated teeth, bleaching agents comparison

1. Introduction

Tooth discoloration, particularly of non-vital teeth, is a common aesthetic concern in dental practice. Among the various treatment modalities available for managing intrinsic discoloration, the walking bleach technique has emerged as a popular and conservative approach for whitening endodontically treated teeth [1]. This technique involves the placement of a bleaching agent- commonly hydrogen peroxide, carbamide peroxide, or sodium perborate- within the pulp chamber, which is then sealed and left in place for a designated period to achieve whitening through oxidation reactions [2].

Despite its proven efficacy in tooth whitening, the walking bleach technique is not without drawbacks. Several studies have raised concerns regarding the potential weakening of tooth structure following internal bleaching. Repeated exposure to bleaching agents may adversely affect the physical properties of dentin, leading to reduced microhardness, degradation of the collagen matrix, and ultimately, increased susceptibility to fracture. This is particularly critical in anterior teeth, where aesthetic demands are high and structural integrity is paramount.

Carbamide peroxide and sodium perborate are commonly used bleaching agents in dentistry. These agents break down to release hydrogen peroxide, which serves as the active ingredient. Due to its low molecular weight, hydrogen peroxide can penetrate dentin, where it releases nascent oxygen to break dimer bonds of organic and inorganic compounds within the dentin tubules. This process chemically reduces colored agents, converting them into colorless compounds. Some studies have indicated that bleaching agents can weaken the bond strength of tooth structures. To prevent bleaching agents from infiltrating the pulp canal, a protective base is always applied to seal the root canal. Various materials have been suggested for this purpose, including zinc oxide eugenol and zinc phosphate. Currently, resin-modified glass ionomer cement (RMGIC) or conventional glass ionomer cement (GIC) is the most commonly used intra-orifice sealer.

However, these materials pose a risk of microleakage, which can lead to external cervical resorption. While most studies focus on assessing the microleakage of these materials, the potential reduction in tooth strength is often overlooked. Therefore, it is crucial to compare the effectiveness of newer restorative materials used as intra-orifice barriers and identify the most suitable option that also reinforces the tooth structure. Bulk-fill composite, fowable composite, Mineral trioxide aggregate (MTA), and Biodentine™ (Septodont) are alternative restorative materials that can be used as intra-orifice barriers. MTA has been extensively studied for various applications in dentistry. It is a powder composed of fine hydrophilic particles that set in the presence of moisture. Notable properties of MTA include superior marginal adaptation and resistance to marginal leakage. Additionally, its fine particle size improves handling. Roghanizad and Jones first proposed the use of intraorifice barriers in root canal-treated teeth for the prevention of coronal microleakage. Subsequent studies evaluated its advantages in enhancing tooth resistance to fracture following endodontic treatment.

During canal preparation, the greater taper of rotary instruments increases the risk of fracture in the coronal third of the tooth, making it crucial to reinforce these vulnerable areas. While various materials have been used as intra-orifice barriers, there is limited research on their effectiveness in enhancing tooth strength and fracture resistance. However, dentin replacement materials such as Biodentine, resin-modified glass ionomers (RMGIs), and advanced nanohybrid composites offer improved physical properties, making them potential options for reinforcement.

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2. Materials and Methods

Eighty-one freshly extracted, intact human single-rooted incisors, canines, and premolars were disinfected by immersing them in normal saline solution for 10 minutes and then stored in 10% formalin at room temperature.

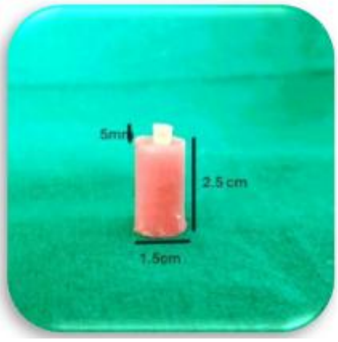
Sodium perborate and hydrogen peroxide (LOBA CHEME PVT LTD)

35% carbamide peroxide (PREVEST DENPRO)

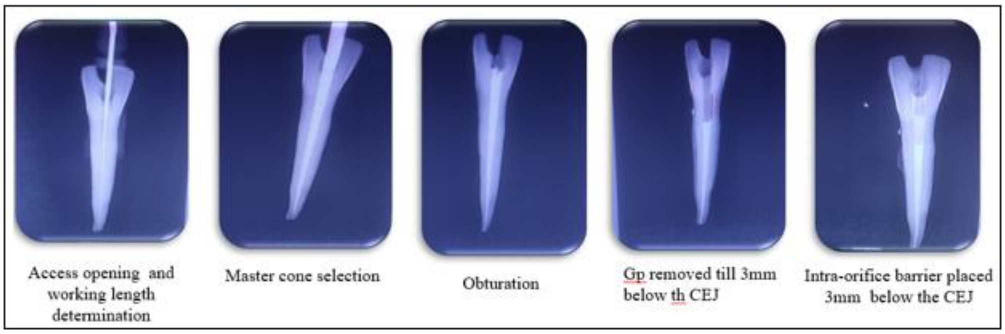
Eighty-one freshly extracted, intact human single-rooted incisors, canines, and premolars were disinfected by immersing them in normal saline solution for 10 minutes and then stored in 10% formalin at room temperature.

Inclusion criteria
- Single-rooted teeth (incisors, canines, premolars)
- Teeth without developmental anomalies
- Exclusion criteria
- Severely curved or calcified root canals.
- Previously endodontically treated teeth and those with enamel or dentin fractures, caries, or other structural damage.

Before root canal treatment and bleaching procedure, teeth were fixed in a cold cure resin cylinder with the labial aspect of the tooth perpendicular to the table surface with a width of 1.5cm and height of 2.5 cm in such a way that 5 mm of root structure was available outside the resin block.

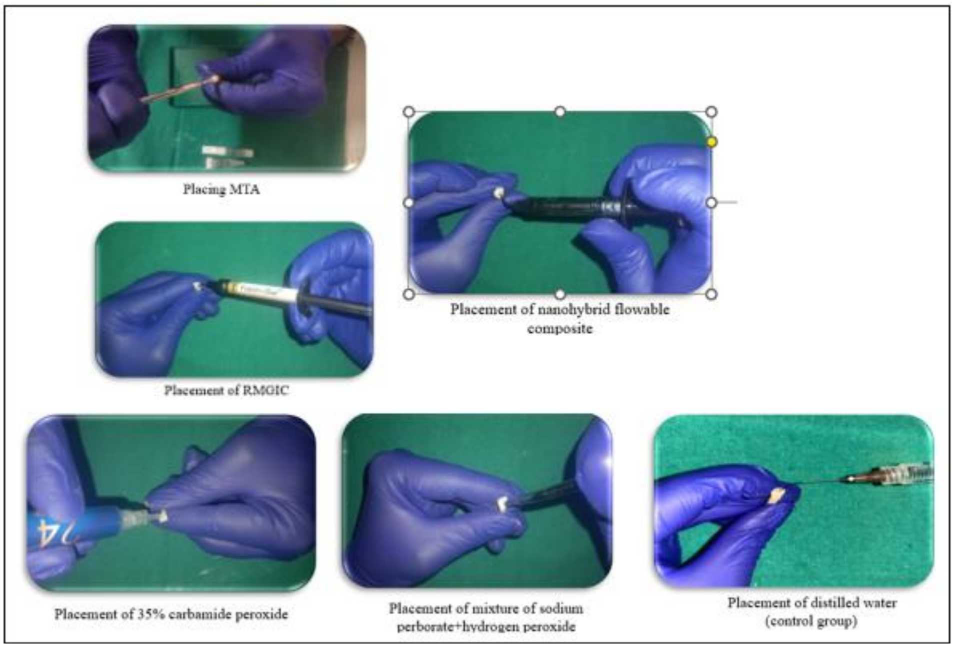


Preoperative radiographs were taken using radiovisiography (RVG). Access cavity on the teeth was prepared using endo-access bur, and canal negotiation was done with number 10 K-file followed by radiographic confirmation of the working length. Biomechanical preparation was performed with rotary instrumentation. Apical preparation for all teeth was done up to 25 6%, with Neo endo (diameter: 0.25 mm; taper: 6%). Sodium hypochlorite 5.25% and 17% ethylene diamine tetraacetic acid (EDTA) were used as root canal irrigants for the entire procedure. After cleaning and shaping, radiographs were taken with the master cone in the root canal. Single cone obturation was done by using gutta-percha, with zinc oxide eugenol as a sealer. After radiographic evaluation of obturated teeth, 3 mm of coronal gutta-percha was removed from the cemento-enamel junction (CEJ) using a peeso reamer. Samples were again evaluated radiographically.



Then, the endodontically treated teeth were randomly categorized into three groups. In each group, different intra-orifice barriers were placed at the level of CEJ for a thickness of 3 mm.

Group 1: resinmodified glass ionomer cement (RMGIC); placed at the level of CEJ and cured for 20 seconds. Group 2: MTA; powder and liquid were mixed according to the manufacturer's instructions and placed at the level of CEJ and waited for 24 hours to set. Group 3: nano hybrid flowable composite; placed at the level of CEJ and light-cured for 20 seconds. Radiographs were taken to confirm the thickness of the intra-orifice barrier. After that, each group's samples were randomly divided into three subgroups: A, B, and C (n=9). Group A was treated with 35% carbamide peroxide (prevest denpro 24 karat). Group B was bleached with mixture of sodium perborate and hydrogen peroxide. Group C, which was the control group, was treated with distilled water. In each group, bleaching material was placed inside the pulp chamber and access was restored with temporary restoration (Cavit G). The bleaching procedure was repeated once every seven days for a period of three weeks. During this period, teeth were incubated in normal saline at 37 °C. After bleaching, every sample was sectioned 2 mm above the level of CEJ by using a diamond disc to remove the crown.



Measurement of fracture resistance A universal testing machine (UTM) was used for the evaluation of fracture resistance of teeth. The perpendicular force was applied to the center of the decoronated tooth at a rate of 1 mm/minute by using a blunt indenter.

3. Results

Table 1: Intra-Group Fracture Resistance of Group 1 (RMGIC) with Different Treatments

Sub Groups	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		F value	P value
					Lower Bound	Upper Bound		
35% CP	9	306.67	78.740	26.247	246.14	367.19	2.428	0.111
SP+HP	9	287.50	31.960	11.299	260.78	314.22		
CONTROL	9	346.67	46.904	15.635	310.61	382.72		
Total	27	314.62	60.015	11.770	290.37	338.86		

Test done: One-way ANOVA; p≤0.05 was considered statistically significant

Table 2: Intra-Group Fracture Resistance of Group 2 (MTA) with Different Treatments

Sub Groups	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		F value	P value
					Lower Bound	Upper Bound		
35% CP	9	244.44	34.319	11.440	218.06	270.82	19.226	<0.001*
SP+HP	9	145.00	42.426	15.000	109.53	180.47		
CONTROL	9	222.22	25.386	8.462	202.71	241.74		
Total	27	206.15	53.894	10.570	184.39	227.92		

Test done: One-way ANOVA; p≤0.05 was considered statistically significant

Table 3: Intra-Group Fracture Resistance of Group 3 (Flowable Nano Hybrid Composite) with Different Treatments

Sub Groups	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		F value	P value
					Lower Bound	Upper Bound		
35% CP	9	282.22	39.299	13.100	252.01	312.43	26.096	<0.001*
SP+HP	9	315.00	25.635	9.063	293.57	336.43		
CONTROL	9	386.67	26.458	8.819	366.33	407.00		
Total	27	328.46	54.310	10.651	306.53	350.40		

Test done: One-way ANOVA; p≤0.05 was considered statistically significant

The tables present the **fracture resistance** of different subgroups within three material groups: **Group 1 (RMGIC), Group 2 (MTA), and Group 3 (Flowable Nano Hybrid Composite).** A one-way ANOVA test was conducted for each group to determine statistical significance (p≤0.05).

Table 1 (Group 1 - RMGIC) shows that there were no statistically significant differences in fracture resistance among the subgroups (p=0.111), though the control group exhibited the highest mean fracture resistance.

Table 2 (Group 2 - MTA) reveals a statistically significant difference in fracture resistance among the subgroups (p<0.001), with the **SP+HP** subgroup demonstrating the lowest mean fracture resistance, while the **35% CP** and control groups exhibited higher values.

Table 3 (Group 3 - Flowable Nano Hybrid Composite) also shows a significant difference in fracture resistance (p<0.001), with the control subgroup displaying the highest mean fracture resistance, followed by **SP+HP**, while **35% CP** had the lowest value.

Table 4: Inter-Group Fracture Resistance of Subgroup A (35% CP) Across Different Materials

Groups	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		F value	P value
					Lower Bound	Upper Bound		
1	9	306.67	78.740	26.247	246.14	367.19	3.497	0.04*
2	9	237.50	29.155	10.308	213.13	261.87		
3	9	282.22	39.299	13.100	252.01	312.43		
Total	27	276.92	59.516	11.672	252.88	300.96		

Test done: One-way ANOVA; p≤0.05 was considered statistically significant.

Table 4 presents the **inter-group comparison** of fracture resistance for **Subgroup A (35% CP) across different materials**. A one-way ANOVA test revealed a **statistically significant difference** among the groups (**p = 0.04**). The highest mean fracture resistance was observed in **Group 1 (RMGIC) (306.67 ± 78.74 N)**, followed by **Group 3 (Flowable Nano Hybrid Composite) (282.22 ± 39.30 N)**, while **Group 2 (MTA) exhibited the lowest mean fracture resistance (237.50 ± 29.16 N)**. These results suggest that the type of restorative material significantly influences fracture resistance within Subgroup A (35% CP), with RMGIC demonstrating the highest strength among the tested materials.

Table 5: Inter-Group Fracture Resistance of Subgroup B (SP+HP) Across Different Materials

Groups	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		F value	P value
					Lower Bound	Upper Bound		
1	9	286.67	30.000	10.000	263.61	309.73	42.964	<0.001*
2	9	157.50	75.923	26.843	94.03	220.97		
3	9	311.43	25.448	9.619	287.89	334.96		
Total	27	250.83	82.983	16.939	215.79	285.87		

Test done: One-way ANOVA; p≤0.05 was considered statistically significant

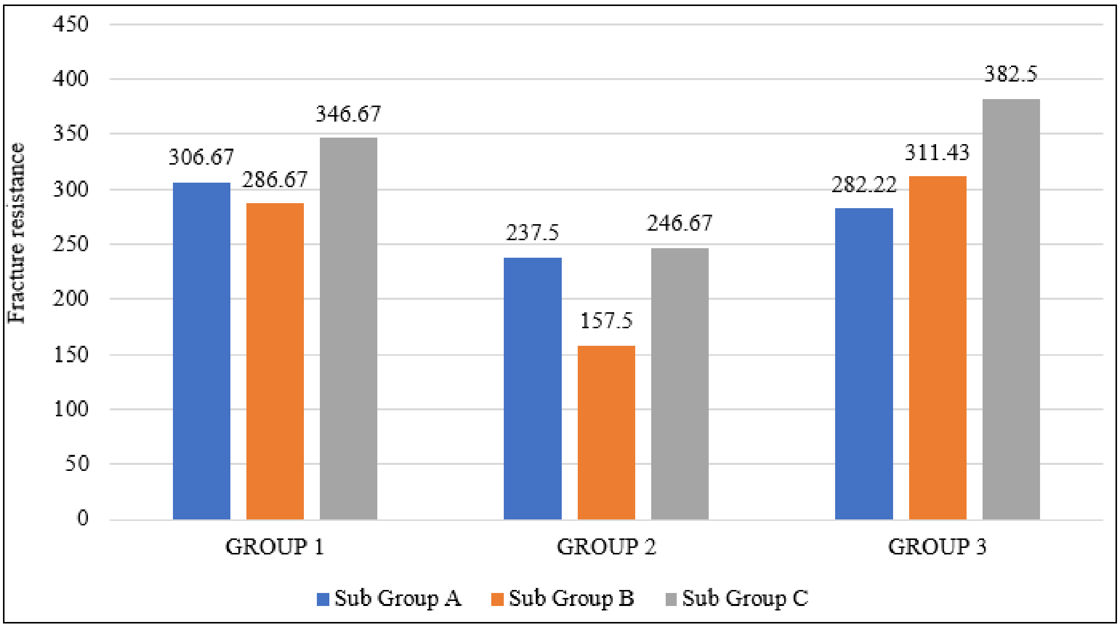
Table 5 presents the **inter-group comparison** of fracture resistance for **Subgroup B (SP+HP) across different materials**. A one-way ANOVA test showed a **highly significant difference** among the groups (**p < 0.001**). The highest mean fracture resistance was observed in **Group 3 (Flowable Nano Hybrid Composite) (311.43 ± 25.45 N)**, followed closely by **Group 1 (RMGIC) (286.67 ± 30.00 N)**, while **Group 2 (MTA) exhibited the lowest mean fracture resistance (157.50 ± 75.92 N)**.

Table 6: Inter-Group Fracture Resistance of Subgroup C (CONTROL) Across Different Materials

Groups	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		F value	P value
					Lower Bound	Upper Bound		
1	9	346.67	46.904	15.635	310.61	382.72	16.350	<0.001*
2	9	246.67	69.282	23.094	193.41	299.92		
3	9	382.50	24.928	8.814	361.66	403.34		
Total	27	323.08	76.460	14.995	292.19	353.96		

Test done: One-way ANOVA; $p \leq 0.05$ was considered statistically significant

Table 6 presents the **inter-group comparison** of fracture resistance for **Subgroup C (Control) across different materials**. A one-way ANOVA test revealed a **highly significant difference** among the groups (**$p < 0.001$**). The highest mean fracture resistance was observed in **Group 3 (Flowable Nano Hybrid Composite) (382.50 ± 24.93 N)**, followed by **Group 1 (RMGIC) (346.67 ± 46.90 N)**, while **Group 2 (MTA) had the lowest mean fracture resistance (246.67 ± 69.28 N)**.



4. Discussion

This in vitro study evaluated the effect of various bleaching agents and intra-orifice barriers on the fracture resistance of endodontically treated teeth.

Walking bleach was performed with either 35% carbamide peroxide or mixture of sodium perborate and hydrogen peroxide for a period of three weeks. Root canal orifices were sealed at the level of CEJ with three different barriers. RMGIC, MTA and nano hybrid flowable composite; 35% carbamide peroxide or mixture of sodium perborate and hydrogen peroxide did not have any statistically significant effect on fracture resistance of teeth. Except for nano hybrid flowable composite, the intra-orifice barriers did not significantly affect the fracture resistance.

Several studies have investigated the fracture resistance of endodontically treated teeth reinforced with various intraorifice barrier materials, including nano-hybrid flowable composites, resin-modified glass ionomer cement (RMGIC), and mineral trioxide aggregate (MTA). The findings regarding the effectiveness of these materials are mixed.

For instance, a study published in the *Indian Journal of Dental Sciences* reported that nano-hybrid composite used as an intraorifice barrier exhibited the highest fracture resistance, followed by Cention N, MTA, and a control group without any barrier. The integration of nano-sized fillers in nano-hybrid composites improves their fracture toughness, making them more resistant to crack propagation.

It also exhibits higher flexural strength due to their optimized filler content and particle size distribution. This increased strength enables the material to withstand masticatory forces more effectively, reducing the likelihood of restoration failure. Conversely, another study published in the *Journal of Conservative Dentistry* found that RMGIC provided the highest reinforcement, followed by fiber-reinforced composite (FRC), nano-hybrid composite, and MTA. This study concluded that while all tested intraorifice barriers increased fracture resistance compared to the control, RMGIC was the most effective among them. The discrepancies in various studies suggest that the reinforcing effect of intraorifice barrier materials may vary depending on factors such as study design, material properties, and application techniques.

Carbamide peroxide or mixture of sodium perborate and hydrogen peroxide with Nano hybrid flowable composite did not show a statistically significant difference in the reduction of fracture resistance.

5. Conclusion

Walking bleaching using 35% carbamide peroxide or a combination of sodium perborate and hydrogen peroxide reduces the fracture resistance of endodontically treated teeth. While the sodium perborate and hydrogen peroxide mixture results in a greater reduction in fracture resistance compared to carbamide peroxide, the difference is not statistically significant.

The use of intra-orifice barriers enhances fracture resistance and reinforces endodontically treated teeth undergoing the walking bleach procedure. GC G-aenial Universal Flo nano-hybrid composite serves as an effective intra-orifice barrier, providing good fracture resistance.

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